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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B23B 27/16 | A1 | (11) International Publication Number: WO 98/33615

(43) International Publication Date: 6 August 1998 (06.08.98)

(21) International Application Number: PCT/IL97/00374

(22) International Filing Date: 17 November 1997 (17.11.97)

(30) Priority Data:
120137 3 February 1997 (03.02.97) IL

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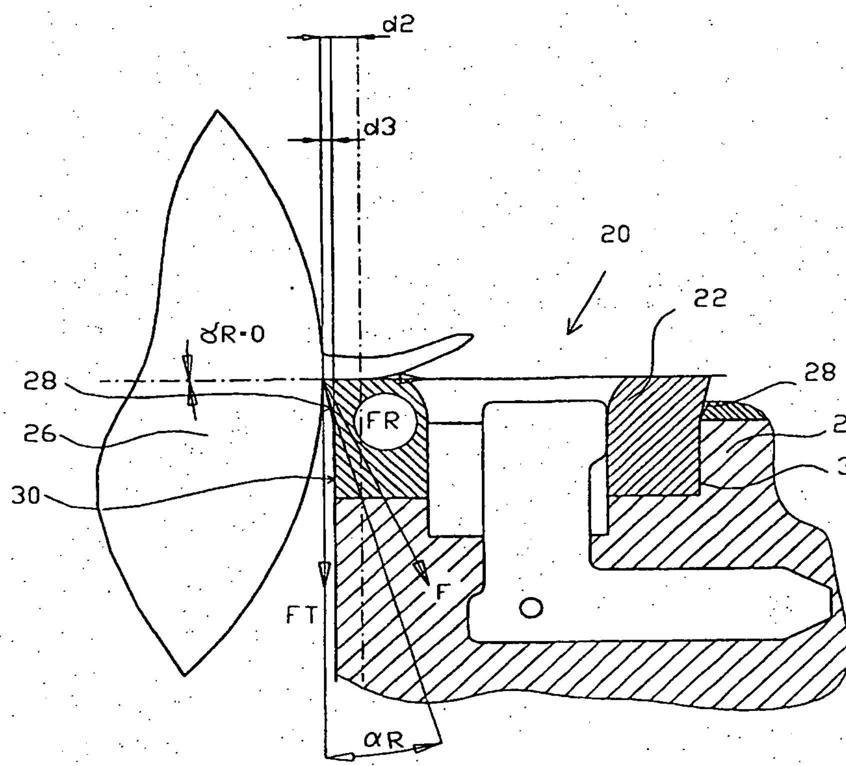
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
With amended claims.

(54) Title: CUTTING INSERTS

(57) Abstract

A cutting insert (22) has an upper rake surface, peripheral flank surfaces, a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge. The peripheral flank surfaces of the cutting insert include a first flank surface portion (28) bounded in part by the cutting edge and in part by a lower boundary, the first flank surface portion having a primary positive relief angle, and a second flank surface portion (30) extending from the lower boundary towards the base, the second flank surface portion having a relief angle no greater than about zero. The positive relief angle is typically less than about 30°, and preferably between about 4° and about 20°. Optionally, the peripheral flank surfaces may further include a third flank surface portion (40) extending from adjacent to the second flank surface portion towards the base, the third flank surface portion having a secondary positive relief angle.



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CUTTING INSERTS

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to indexable cutting inserts for cutting operations and, in particular, it concerns the geometry of peripheral relief surfaces of such inserts. The present invention also relates to cutting tool holders and assemblies employing inserts of this type.

It is known to employ tools fitted with replaceable cutting inserts of various shapes to cut metals. In order to prevent the insert from rubbing against the workpiece, referred to as "heal-dragging", which causes unnecessary wear and heating, it is necessary to provide a clearance angle between the relief surface of the insert behind the cutting edge and the surface being machined.

As is schematically illustrated in Figures 1 and 2, conventional cutting inserts may be broadly classified into two types: negative inserts, in which radial and axial clearance angles α_R and α_A (only α_R being shown) depend on "double tilting" of the insert with respect to the surfaces being cut; and positive inserts, in which the intrinsic geometry of the insert with built-in positive relief angles provides sufficient clearance angles, thereby allowing an option of mounting the cutting insert rake face normally to the surfaces being cut.

Figure 1 shows schematically a cutting tool assembly employing a negative insert **10** mounted in a tool holder **12** to cut a rotating workpiece **14**. Insert **10** is termed "negative" since its intrinsic relief angle is no greater than

0°. This necessitates negative angling of the insert mounting surfaces of tool holder **12** so as to generate the required clearance angles α_R and α_A (only α_R being shown).

Also shown in Figure 1 are the typical in-plane components of the cutting forces, in which $\mathbf{F}_T$ represents the tangential component of the cutting forces, i.e., the cutting force generated in the primary cutting direction corresponding to the primary direction of relative motion between insert **10** and workpiece **14**, and $\mathbf{F}_R$ represents the radial component of the cutting forces, which takes on a significant magnitude primarily during plunge grooving or similar procedures. Under almost all machining conditions, tangential force $\mathbf{F}_T$ is much greater than either radial force $\mathbf{F}_R$ or axial force $\mathbf{F}_A$ (not shown).

As a result of the orientation of the abutment surfaces of tool holder **12**, the closest part of tool holder **12** available to react against tangential force $\mathbf{F}_T$ is displaced laterally by a distance $\mathbf{d}_1$ from the line of action of tangential force $\mathbf{F}_T$. This displacement results in a large bending moment acting on the insert corner causing significant bending stress which is additive to the transverse shear stress (combined via, for example, Tresca's failure hypothesis), wherein both stresses are directly proportional to $\mathbf{F}_T$. Practically speaking, two independent measures can be employed in order to reduce the combined stress: 1) providing a chip forming groove in the rake face behind the cutting edge and 2) sloping the main cutting edge from the cutting corner to the base of the insert. These measures render the simple rake angle (definition provided below)

less negative and produce an acute cutting edge wedge angle, all of which contributes to reducing $\mathbf{F}_T$.

An obvious advantage of negative inserts is the simple orthogonal geometry of the base and lateral abutment surfaces of the insert receiving pocket of the tool holder. Another advantage of negative inserts derives from the fact that the insert is naturally restrained by the up-right rear abutment surfaces of the insert receiving pocket against up-ending due to the aforementioned bending moment.

Figure 2 shows schematically a cutting tool assembly employing a positive insert **16** mounted in a tool holder **18** to cut a rotating workpiece **14**. Insert **10** is termed "positive" since its intrinsic relief angles are positive, thereby providing sufficient clearance angles α_R and α_A when positioned in a tool holder with a base abutment surface perpendicular to the primary cutting direction. In the case of a positive insert, the rear abutment surfaces of the insert receiving pocket must be correspondingly outwardly sloped.

Also shown in Figure 2 are the typical in-plane components of the cutting forces. Here, the closest part of tool holder **18** available to react against tangential force $\mathbf{F}_T$ is displaced laterally by distance $\mathbf{d}_2$ from the line of action of tangential force $\mathbf{F}_T$. For a hypothetical situation where the clearance angle and the height of the insert is the same as for the negative insert shown in Figure 1, naturally $\mathbf{d}_2 = \mathbf{d}_1$. Such a case actually exist wherein a relief angle of a positive insert equals the tilt angle of a negative insert tool holder, at about 6°.

Thus, it would appear that the stress problem is shared by positive inserts. In fact, the positive rake angles of positive inserts tend to ameliorate the cutting forces. However, a different problem is created by the resultant bending moment which tends to up-end the insert. Since the outwardly sloped rear abutment surfaces of the insert receiving pocket is ineffective at resisting this up-ending moment, a heavy burden is placed on the clamping mechanism. As a result, the more convenient clamping techniques such as bottom lever clamping are typically insufficient, and clamping from the top of the insert, for example, by means of screw clamping (as shown), becomes necessary.

Reference will now be made to two particular patent publications, namely, European Patent Publication 160,278 A2 and UK Patent Publication 2.156,254 A. In order not to confuse the reader, it should be pointed out that these references do not constitute particularly relevant background to the present invention. However, they are cited here because of a superficial similarity they bear to the present invention, and for the purpose of setting out the clear differences between the structures described therein and that of the present invention.

Referring first to the European publication, this relates to controlling the axial run-out of a cutting insert for a face milling cutter by grinding a relief flank surface of the insert. Reference is made to a "conventional insert" in which the periphery of the insert includes a standard positive-type relief surface adjacent to the cutting edge, and a "rearward portion ... offset inwardly

throughout the entire periphery thereof to provide a clearance portion". This clearance portion allows a grinding operation to be performed exclusively on the forward relief surfaces, thereby saving time and labor. However, the offsetting of the rearward flank surface generates an unnecessary overhang of the cutting edge, thereby **reducing** the structural support to the cutting edge compared with a corresponding standard positive insert.

Turning now to the UK publication, this relates to a milling cutter in which the inserts are placed tangentially or "on-edge", as opposed to being radially placed in the conventional manner. The insert is attached by the use of a screw passing through a hole in the relief flank surface. Unlike in conventionally placed inserts, here the radial rake angle is determined by the design of the peripheral edge surfaces. Adjoining a pair of opposite cutting edges are composite rake surfaces having two surface portions of which a first, adjacent the base surface, is normal to the base surface and a second, adjacent to the cutting edge, has a positive rake angle. The superficial similarity of this insert structure to those of the present invention is solely to the extent that the eye may be mislead by a view of the cross-section of the insert to interpret the composite rake surfaces as relief surfaces and vice-versa. However, on further consideration, it will be abundantly clear to anyone ordinarily skilled in the art that neither the conceptual considerations nor the structural features of the rake surface of the aforementioned UK publication bear any relation to the relief flank surface structures of the present invention.

There is therefore a need for a geometry of relief flank surface which provides sufficient cutting edge clearance to allow the insert to be mounted with zero radial and axial rakes, while providing improved structural integrity and support for the cutting edge. It would also be advantageous to have a cutting tool assembly which allows the insert to be mounted with zero radial and axial rakes, while simultaneously allowing use of an insert receiving pocket with simple orthogonal definition of abutment surfaces, as well as facilitating the use of bottom lever clamping.

SUMMARY OF THE INVENTION

The present invention is a cutting insert structure in which the peripheral flank surfaces provide sufficient cutting edge clearance to allow the insert to be mounted with zero radial and axial rake, while providing improved structural integrity and support for the cutting edge.

According to the teachings of the present invention there is provided, a cutting insert having an upper rake surface, peripheral flank surfaces, a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge, the cutting insert being characterized in that the peripheral flank surfaces include: (a) a first flank surface portion bounded in part by the cutting edge and in part by a lower boundary, the first flank surface portion having a primary positive relief angle; and (b) a second flank surface portion extending from the

lower boundary towards the base, the second flank surface portion having a relief angle no greater than about zero.

According to a further feature of the present invention, the positive relief angle is less than about 30°.

According to a further feature of the present invention, the positive relief angle is between about 4° and about 20°.

According to a further feature of the present invention, the second flank surface portion has a relief angle substantially equal to zero.

According to a further feature of the present invention, the upper rake surface is formed with at least one feature for chip control.

According to a further feature of the present invention, the peripheral flank surfaces further include a third flank surface portion extending from adjacent to the second flank surface portion towards the base, the third flank surface portion having a secondary positive relief angle.

According to a further feature of the present invention, the secondary positive relief angle is greater than about 10°.

According to a further feature of the present invention, the cutting insert is symmetrical under rotations of 360°/n where n is at least 3.

According to a further feature of the present invention, the first flank portion is shaped such that a cross-section of the cutting insert taken perpendicular to the central axis proximal to the at least one cutting edge exhibits n corners where n is at least 3, each of the corners being formed

between two substantially straight lines, wherein the internal angle between the substantially straight lines is less than (180° - 360°/n).

According to a further feature of the present invention, there is provided a cutting tool assembly comprising: (a) the cutting insert described above; and (b) a tool holder having at least one insert receiving pocket for receiving the cutting insert, the insert receiving pocket having a base abutment surface, and a first rear abutment surface perpendicular to the base abutment surface.

According to a further feature of the present invention, the insert receiving pocket further includes a second rear abutment surface perpendicular to the base abutment surface and forming an open angle of less than about 120° with the first rear abutment surface.

According to a further feature of the present invention, the second rear abutment surface forms an open angle of not more than about 90° with the first rear abutment surface.

According to a further feature of the present invention, the second rear abutment surface forms an open angle of less than 90° with the first rear abutment surface.

There is also provided according to the teachings of the present invention, a tool holder for receiving a cutting insert having an upper flank surface portion with a positive relief angle adjacent to a cutting edge, and a lower flank surface portion with a zero relief angle, the tool holder comprising: (a) at least one reference feature for defining a plane corresponding to a plane

of zero axial and radial rake when the tool holder is in use; and (b) at least one insert receiving pocket, the insert receiving pocket having a base abutment surface substantially parallel to the plane, and a first rear abutment surface perpendicular to the base abutment surface for abutting the lower flank surface portion of the insert.

According to a further feature of the present invention, the insert receiving pocket further includes a second rear abutment surface perpendicular to the base abutment surface and forming an open angle of less than about 120° with the first rear abutment surface.

According to a further feature of the present invention, the second rear abutment surface forms an open angle of not more than about 90° with the first rear abutment surface.

According to a further feature of the present invention, the second rear abutment surface forms an open angle of less than 90° with the first rear abutment surface.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic side cross-sectional view of a conventional cutting tool including a negative cutting insert being used to cut a rotating workpiece;

FIG. 2 is a schematic side cross-sectional view of a conventional cutting tool including a positive cutting insert being used to cut a rotating workpiece;

FIG. 3 is a schematic side cross-sectional view of a first preferred embodiment of a cutting tool assembly, constructed and operative according to the teachings of the present invention, being used to cut a rotating workpiece;

FIG. 4 is an isometric view of a cutting insert of the assembly of Figure 3;

FIG. 5 is a schematic side cross-sectional view of a second preferred embodiment of a cutting tool assembly, constructed and operative according to the teachings of the present invention, illustrating additional features for cutting an internal surface of rotating workpiece;

FIG. 6 is an isometric view of a cutting insert of the assembly of Figure 5;

FIG. 7A is an isometric view of a cutting insert for use in a third preferred embodiment of a cutting tool assembly, constructed and operative according to the teachings of the present invention;

FIG. 7B is a top view of the cutting insert of Figure 7A;

FIG. 7C is a partial cross-sectional view taken along the line A-A of Figure 7B;

FIG. 7D is a side view of the cutting insert of Figure 7A;

FIG. 8A is a side view of the third preferred embodiment of a cutting tool assembly, constructed and operative according to the teachings of the present invention, in which the insert of Figure 7A is mounted in a tool holder;

FIG. 8B is a front view of the cutting tool assembly of Figure 8A;

FIG. 8C is a top view of the cutting tool assembly of Figure 8A;

FIG. 9A is a side view of the tool holder of Figure 8A;

FIG. 9B is a front view of the tool holder of Figure 8A; and

FIG. 9C is a top view of the tool holder of Figure 8A.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a cutting insert structure in which the peripheral flank surfaces provide sufficient cutting edge clearance to allow the insert to be mounted with zero radial and axial rake, while providing improved structural integrity and support for the cutting edge. The invention also provides a tool holder for use with such an insert structure which has an insert pocket presenting zero axial and radial rake while having a simple orthogonal definition for its abutment surfaces.

The principles and operation of cutting inserts according to the present invention may be better understood with reference to the drawings and the accompanying description.

Before proceeding with a detailed description of the preferred embodiments of the present invention, it will be helpful to define certain

terminology which will be employed herein in the specification and claims to refer to various angles. In this regard, it should be noted that, wherever reference is made to an angle between a line and a plane, the angle concerned is hereby defined to be the angle between the line and its own orthogonal projection on to the plane, unless specified otherwise.

Firstly, with respect to the intrinsic geometry of an insert considered independent of a specific cutting tool arrangement, reference is made to a central axis of rotational symmetry about which the entire insert, including its one or more cutting edges, exhibits n-fold rotational symmetry where n is at least two. For convenience of reference, the central axis of rotational symmetry of an insert will be termed “the central axis” of the insert.

The “relief angle” α of a part of a flank surface of an insert is then defined as the angle between the central axis and the plane of the flank surface. In the case of a non-planar flank surface (as is always the case for a circular insert), the relief angle is evaluated using a plane defined by the local inclination of the flank surface at a given point. The sign of the relief angle is defined to be positive for a surface which becomes more distant from the central axis in an upwards direction from the base towards the upper surface of the insert.

When referring to inclination of surfaces of a cutting insert mounted in a tool holder, tool-rake and clearance angles are defined relative to axial and radial directions defined by the relative motion of the tool and the workpiece.

Specifically, the axial direction is defined to be parallel to a primary axis of rotation, either of the workpiece or of a rotary cutting tool (for example, used in milling or drilling). The radial direction connects between that axis and the surface in question. Thus, the radial and axial tool-rake angles γ_R and γ_A of an upper rake surface are defined as the angles between the rake surface and the aforementioned radial and axial directions, respectively. With respect to clearance angles, the radial clearance angle α_R of a part of a flank surface oriented in the axial direction is defined as the angle between a line mutually perpendicular to both the radial and axial directions and (a radial projection of that line on to) the part of the flank surface. Similarly, the axial clearance angle α_A of a part of a flank surface oriented in the radial direction is defined as the angle between a line mutually perpendicular to both the radial and axial directions and (an axial projection of that line on to) the part of the flank surface.

In a further issue of terminology, it should be noted that the rake angle referred to in the context of the present description is that of the overall disposition of the upper surface of a cutting insert, independent of the detailed geometrical form adjacent to the cutting edge. Thus, as a result of the rotational symmetry of the cutting inserts in question, the plane of the rake surface is defined to be perpendicular to the central axis. As a further result of the same symmetry, it follows that the predominant plane of the base of the cutting insert, and hence the inclination of a base abutment surface of a tool holder, are

also parallel to the rake surface. The axial and radial rake angles are thus a direct indication of the inclination of a base abutment surface of a tool holder in two directions.

Turning now to the drawings, Figure 3 illustrates schematically a first embodiment of a cutting tool assembly, generally designated **20**, constructed and operative according to the teachings of the present invention, which employs a cutting insert **22** mounted in a tool holder **24** to cut a rotating workpiece **26**.

Cutting insert **22** is shown separately in more detail in Figure 4. Generally speaking, the relief flank surface of cutting insert **22** has a relatively small first flank portion **28**, adjacent to the cutting edge, which has a positive relief angle, and a second flank portion **30**, further removed from the cutting edge, which has a non-positive relief angle. First flank portion **28** ensures that there is sufficient clearance under the cutting edge when cutting insert **22** is mounted with zero axial and radial inclination, so long as the flank wear is within acceptable limits. Once sufficient clearance has been guaranteed, second flank portion **30** serves to provide the maximum possible support to the cutting edge.

Comparing Figure 3 with the prior art cutting tools of Figures 1 and 2, it will be noted that the closest part of tool holder **24** available to react against tangential force $\mathbf{F_T}$ is displaced laterally by a distance $\mathbf{d_3}$ from the line of action of tangential force $\mathbf{F_T}$. For the same clearance angles α_R and α_A (not shown),

this displacement is much smaller than the displacements $\mathbf{d}_1$ and $\mathbf{d}_2$ of the respective prior art cutting tools, thereby greatly reducing the bending moment on the insert, and the resultant stress and up-ending moment.

The non-positive relief angle of second flank portion **30** also provides considerable advantages for clamping of cutting insert **22** in tool holder **24**. The resulting up-right rear abutment surfaces of the insert receiving pocket provide effective restraining action against considerable up-ending moments. This allows use of the highly convenient bottom lever clamping to clamp insert **22**. Furthermore, in a preferred embodiment in which second flank portion **30** has a relief angle substantially equal to 0°, the rear abutment surfaces and the base of the insert receiving pocket are mutually perpendicular, thereby facilitating production, and improving precision, of the tool holder.

It should be noted that, although the present invention is illustrated by way of example in the context of an insert with 90° rotational symmetry, it may equally be applied to cutting inserts and corresponding tools with other symmetry. In general terms, cutting inserts of the present invention are symmetrical under rotations of $360°/n$ where n preferably has a value of at least 3, and typically at least four. Also within the scope of the present invention are inserts with circular symmetry ($n \to \infty$).

Figure 5 illustrates a second embodiment of a cutting tool assembly, generally designated **32**, constructed and operative according to the teachings of the present invention, which is especially advantageous for cutting an

internal surface of rotating workpiece **38**. Generally speaking, cutting tool assembly **32**, which includes a cutting insert **34** mounted in a tool holder **36**, is similar to cutting tool assembly **20**, and equivalent features are labeled similarly. In addition, cutting insert **34** features a third relief flank portion **40**, located below second relief flank portion **30**, which has a positive relief angle. Third relief flank portion **40** provides additional clearance to accommodate the internal curvature of workpiece **38**. At the same time, third relief flank portion **40** allows the use of a large fillet radius at the intersection between the base and each of the rear abutment surfaces which tends to reduce stress concentrations. Cutting insert **34** is shown separately in more detail in Figure 6.

Turning now to Figures 7A-7D, these show a third preferred embodiment of a cutting insert, generally designated **50**, constructed and operative according to the teachings of the present invention. Generally speaking, cutting insert **50** is similar to cutting insert **34**, described above, but is formed with recessed side edges. This embodiment is especially advantageous for cutting relatively shallow square shoulders.

Thus, cutting insert **50** features an upper rake surface **52**, peripheral flank surfaces **54**, a base **56**, and a central axis of rotational symmetry **58** (Figure 7D). The intersection between upper rake surface **52** and peripheral flank surfaces **54** forms a cutting edge **60**. Upper rake surface **52** is preferably formed with at least one feature for chip control, exemplified here by chip-breaking groove **53**.

Peripheral flank surfaces **54** include a first flank surface portion **62**, bounded in part by cutting edge **60** and in part by a lower boundary **64**. Peripheral flank surfaces **54** include a second flank surface portion **66**, extending from lower boundary **64** towards base **56**. A third flank surface portion **68** is provided around a part of the periphery of cutting insert **50**, extending from adjacent to second flank surface portion **66** towards base **56**.

As shown in Figure 7C, first flank surface portion **62** has a primary positive relief angle α. Relief angle α is preferably less than about 30°, and typically between about 4° and about 20°. Second flank surface portion **66** has a relief angle no greater than about zero, and typically substantially equal to zero. Third flank surface portion **68** has a secondary positive relief angle β which is typically greater than about 10°.

As mentioned above, cutting insert **50** preferably features recessed side edges especially advantageous for cutting relatively shallow square shoulders. Specifically, first flank portion **62** is preferably shaped such that a cross-section of cutting insert **50** taken perpendicular to central axis **58** close to cutting edge **60** exhibits four outwardly extending corners **70**, each being formed between two approximately straight lines **72** and **74**. Lines **72** and **74** lie inside a virtual line **76** between adjacent corners **70** such that the sides are termed "recessed". The result of this structure is that the angle formed between lines **72** and **74** at each corner is less than 90°. This provides clearance for the inoperative cutting

edges of cutting insert **50** during cutting of shallow square shoulders during a range of cutting operations including, but not limited to, longitudinal turning.

As mentioned earlier, the present invention may be applied to a range of geometries with different rotational symmetry. Thus, in more general terms, cutting insert **50** may be considered to have n corners where n is at least 3, each of the corners being formed between two substantially straight lines. In this general case, the internal angle between the lines at each corner is less than $(180° - 360°/n)$.

It should be noted that reference is made to a cross-section through first flank portion **62** rather than the shape of cutting edge **60**, itself. Typically, the geometry of cutting edge **60** and first flank portion **62** are similar such that this distinction is not critical. The distinction is made, however, to accommodate cases in which the cutting edge is serrated or otherwise irregular.

Turning now to Figures 8A-8C, these show a cutting tool assembly, generally designated **80**, constructed and operative according to the teachings of the present invention, in which cutting insert **50** is mounted within a tool holder **82**. Tool holder **82** is shown separately in Figures 9A-9C.

As best seen in Figures 9A-9C, tool holder **82** features an insert receiving pocket **84** formed with a plurality of abutment surfaces for receiving cutting insert **50**. Specifically, insert receiving pocket **84** has a base abutment surface **86**, and a number of rear abutment surfaces **88**, **90**, **92** and **94**, each of which is orthogonal to base abutment surface **86**. The upper extreme of each

rear abutment surface is provided with an inclined recess surface **96** to accommodate the positive relief flank portion of cutting insert **50**. A bottom lever recess **98** is provided in base abutment surface **86** to receive a lever for lever clamping.

It should be noted that the present invention provides significant advantages when applied to cutting tools with a wide range of axial and radial tool-rake angles. For any given tool-rake angles, the orthogonal abutment surfaces provide a simpler and higher precision structure, and better restraint against up-ending, than a similarly positioned conventional positive insert. Simultaneously, the present invention provides greater clearance angles than a similarly positioned conventional negative insert.

In addition to these general advantages, certain preferred embodiments of the present invention exploit this unique combination of features to simultaneously employ orthogonal abutment surfaces together with zero axial and radial tool-rake angles. Thus, in this case, base abutment surface **86** is parallel to a plane of zero axial and radial tool-rake as defined by reference features such as the upper surface of the shank of tool holder **82**. It should be appreciated that this combination of features is impossible with conventional insert geometries since positive inserts require non-orthogonal abutment surfaces and negative inserts require negative axial and radial rake angles to provide the clearance angles.

The geometry of rear abutment surfaces **88**, **90**, **92** and **94** is complementary to the surfaces of second flank surface portion **66** along two adjacent recessed sides. In order to provide effective restraint against a range of cutting forces which may arise, the rear abutment surfaces preferably include at least two non-parallel surfaces which form between them an open angle of less than about 120°. Preferably, for effective restraint of rotational moments, at least two of the surfaces form between them an open angle of not more than about 90°. In the embodiment illustrated, it should be noted that rear abutment surfaces **90** and **92** form between them an angle of less than 90°, thereby providing particularly secure restraint.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the spirit and the scope of the present invention.

WHAT IS CLAIMED IS:

1. A cutting insert having an upper rake surface, peripheral flank surfaces, a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge, the cutting insert being characterized in that the peripheral flank surfaces include:

(a) a first flank surface portion bounded in part by the cutting edge and in part by a lower boundary, said first flank surface portion having a primary positive relief angle; and

(b) a second flank surface portion extending from said lower boundary towards the base, said second flank surface portion having a relief angle no greater than about zero.

2. The cutting insert of claim 1, wherein said positive relief angle is less than about 30°.

3. The cutting insert of claim 1, wherein said positive relief angle is between about 4° and about 20°.

4. The cutting insert of claim 1, wherein said second flank surface portion has a relief angle substantially equal to zero.

5. The cutting insert of claim 1, wherein the upper rake surface is formed with at least one feature for chip control.

6. The cutting insert of claim 1, wherein the peripheral flank surfaces further include a third flank surface portion extending from adjacent to said second flank surface portion towards the base, said third flank surface portion having a secondary positive relief angle.

7. The cutting insert of claim 6, wherein said secondary positive relief angle is greater than about 10°.

8. The cutting insert of claim 1, wherein the cutting insert is symmetrical under rotations of $360°/n$ where n is at least 3.

9. The cutting insert of claim 1, wherein said first flank portion is shaped such that a cross-section of the cutting insert taken perpendicular to the central axis proximal to the at least one cutting edge exhibits n corners where n is at least 3, each of said corners being formed between two substantially straight lines, wherein the internal angle between said substantially straight lines is less than $(180° - 360°/n)$.

10. A cutting tool assembly comprising:

(a) the cutting insert of claim 1; and

(b) a tool holder having at least one insert receiving pocket for receiving said cutting insert, said insert receiving pocket having a base abutment surface, and a first rear abutment surface perpendicular to said base abutment surface.

11. The cutting tool assembly of claim 10, wherein said insert receiving pocket further includes a second rear abutment surface perpendicular to said base abutment surface and forming an open angle of less than about 120° with said first rear abutment surface.

12. The cutting tool assembly of claim 11, wherein said second rear abutment surface forms an open angle of not more than about 90° with said first rear abutment surface.

13. The cutting tool assembly of claim 11, wherein said second rear abutment surface forms an open angle of less than 90° with said first rear abutment surface.

14. A tool holder for receiving a cutting insert having an upper flank surface portion with a positive relief angle adjacent to a cutting edge, and a lower flank surface portion with a zero relief angle, the tool holder comprising:

(a) at least one reference feature for defining a plane corresponding to a plane of zero axial and radial rake when the tool holder is in use; and

(b) at least one insert receiving pocket, said insert receiving pocket having a base abutment surface substantially parallel to said plane, and a first rear abutment surface perpendicular to said base abutment surface for abutting the lower flank surface portion of the insert.

15. The tool holder of claim 14, wherein said insert receiving pocket further includes a second rear abutment surface perpendicular to said base abutment surface and forming an open angle of less than about 120° with said first rear abutment surface.

16. The tool holder of claim 15, wherein said second rear abutment surface forms an open angle of not more than about 90° with said first rear abutment surface.

17. The tool holder of claim 15, wherein said second rear abutment surface forms an open angle of less than 90° with said first rear abutment surface.

AMENDED CLAIMS
[received by the International Bureau on 28 June 1998 (28.06.98);
original claims 1-17 replaced by new claims 1-19 (4 pages)]

1. A cutting insert having an upper rake surface, peripheral flank surfaces, a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge, the cutting insert being characterized in that the peripheral flank surfaces include:

(a) a first flank surface portion bounded in part by the cutting edge and in part by a lower boundary, said first flank surface portion having a primary positive relief angle; and

(b) a second flank surface portion extending from said lower boundary to adjacent to the base, said second flank surface portion having a relief angle no greater than about zero.

2. The cutting insert of claim 1, wherein said positive relief angle is less than about 30°.

3. The cutting insert of claim 1, wherein said positive relief angle is between about 4° and about 20°.

4. The cutting insert of claim 1, wherein said second flank surface portion has a relief angle substantially equal to zero.

5. The cutting insert of claim 1, wherein the upper rake surface is formed with at least one feature for chip control.

6. The cutting insert of claim 1, wherein the cutting insert is symmetrical under rotations of 360°/n where n is at least 3.

7. The cutting insert of claim 1, wherein said first flank portion is shaped such that a cross-section of the cutting insert taken perpendicular to the

central axis proximal to the at least one cutting edge exhibits n corners where n is at least 3, each of said corners being formed between two substantially straight lines, wherein the internal angle between said substantially straight lines is less than $(180° - 360°/n)$.

8. A cutting tool assembly comprising:

(a) a cutting insert having an upper rake surface, peripheral flank surfaces, a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge, the peripheral flank surfaces including:

(i) a first flank surface portion bounded in part by the cutting edge and in part by a lower boundary, said first flank surface portion having a primary positive relief angle; and

(ii) a second flank surface portion extending from said lower boundary towards the base, said second flank surface portion having a relief angle no greater than about zero; and

(b) a tool holder having at least one insert receiving pocket for receiving said cutting insert, said insert receiving pocket having a base abutment surface configured for abutting the base of said cutting insert and first and second rear abutment surfaces configured for abutting corresponding parts of said second flank surface portion of said cutting insert.

9. The cutting tool assembly of claim 8, wherein said second rear abutment surface forming an open angle of less than about 120° with said first rear abutment surface.

10. The cutting tool assembly of claim 9. wherein said first and second rear abutment surfaces are perpendicular to said base abutment surface.

11. The cutting tool assembly of claim 9. wherein said second rear abutment surface forms an open angle of not more than about 90° with said first rear abutment surface.

12. The cutting tool assembly of claim 9, wherein said second rear abutment surface forms an open angle of less than 90° with said first rear abutment surface.

13. A tool holder for receiving a cutting insert having an upper flank surface portion with a positive relief angle adjacent to a cutting edge. and a lower flank surface portion with a zero relief angle, the tool holder comprising:

(a) at least one reference feature for defining a plane corresponding to a plane of zero axial and radial rake when the tool holder is in use; and

(b) at least one insert receiving pocket, said insert receiving pocket having a base abutment surface substantially parallel to said plane. and first and second rear abutment surfaces perpendicular to said base abutment surface for abutting the lower flank surface portion of the insert.

14. The tool holder of claim 13. wherein said second rear abutment surface forms an open angle of less than about 120° with said first rear abutment surface.

15. The tool holder of claim 14. wherein said second rear abutment surface forms an open angle of not more than about 90° with said first rear abutment surface.

AMENDED SHEET (ARTICLE 19)

16. The tool holder of claim 14. wherein said second rear abutment surface forms an open angle of less than 90° with said first rear abutment surface.

17. A cutting insert having an upper rake surface. peripheral flank surfaces. a base, and a central axis of rotational symmetry, the intersection between the upper rake surface and the peripheral flank surfaces forming at least one cutting edge, the cutting insert being characterized in that the peripheral flank surfaces include:

(a) a first flank surface portion bounded in part by the cutting edge and in part by a lower boundary, said first flank surface portion having a positive relief angle; and

(b) a second flank surface portion extending from said lower boundary towards the base, said second flank surface portion being configured to provide abutment surfaces for restraining the cutting insert within a pocket, said abutment surfaces being perpendicular to the base of the insert.

18. The cutting insert of claim 17, wherein the peripheral flank surfaces further include a third flank surface portion extending from adjacent to said second flank surface portion towards the base. said third flank surface portion having a secondary positive relief angle.

19. The cutting insert of claim 17, wherein the cutting edge is formed with a number of corners, the peripheral flank surfaces further including a number of isolated third flank surface portions extending from adjacent to said second flank surface portion towards the base around parts of the periphery of the cutting insert adjacent to said corners, said third flank surface portions having a secondary positive relief angle.

FIG. 1 (PRIOR ART)

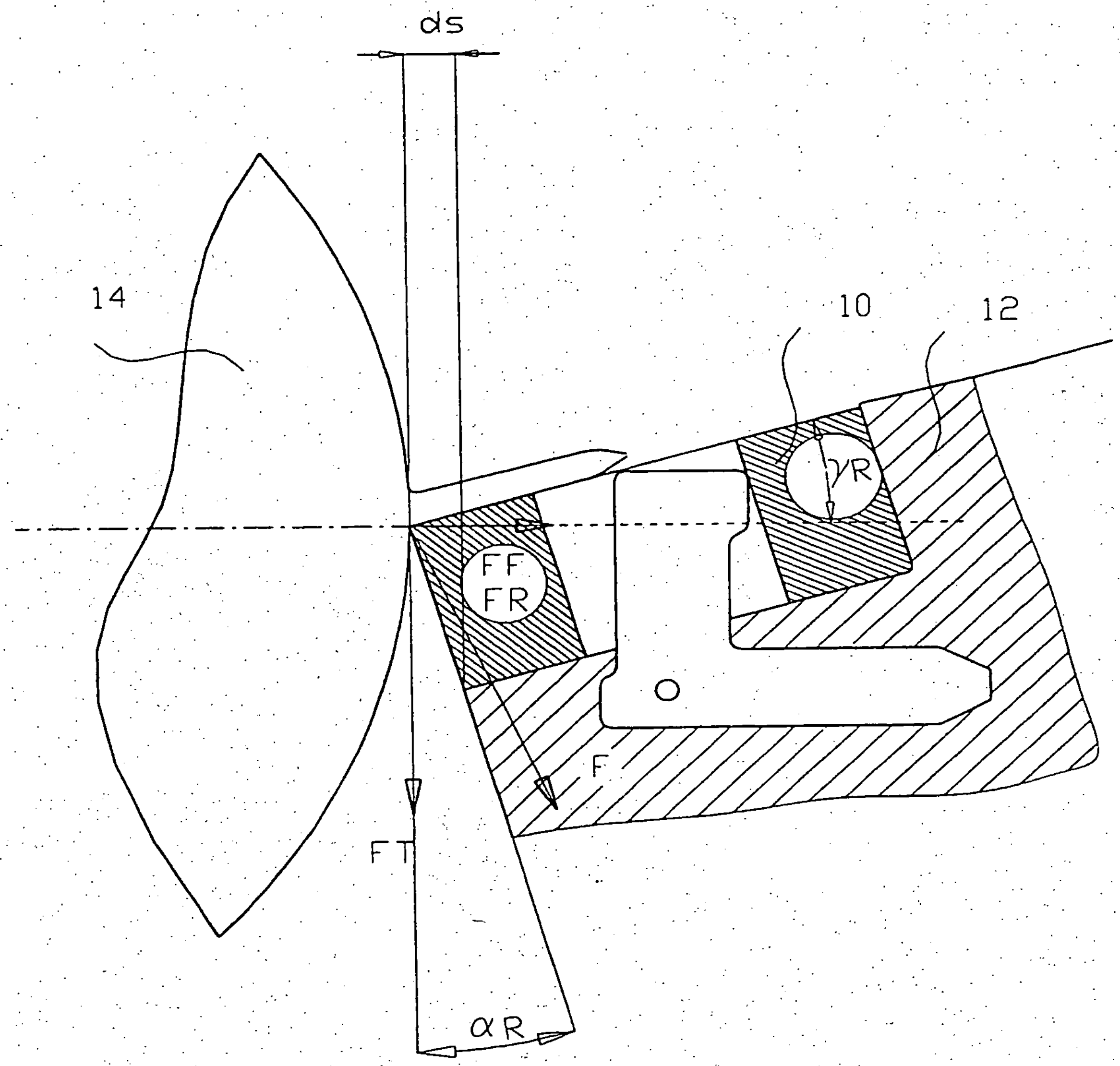

FIG. 2 (PRIOR ART)

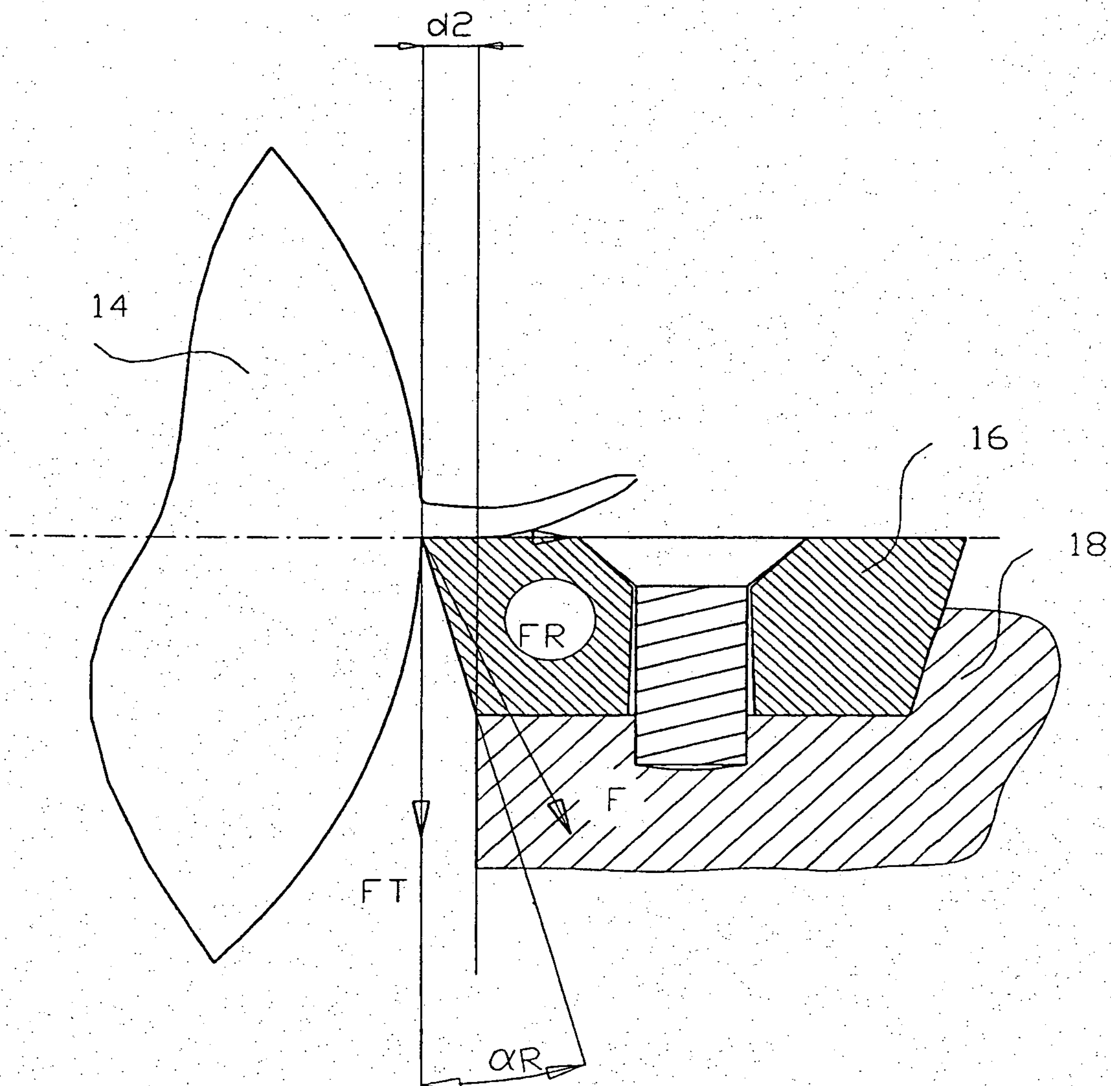

FIG. 3

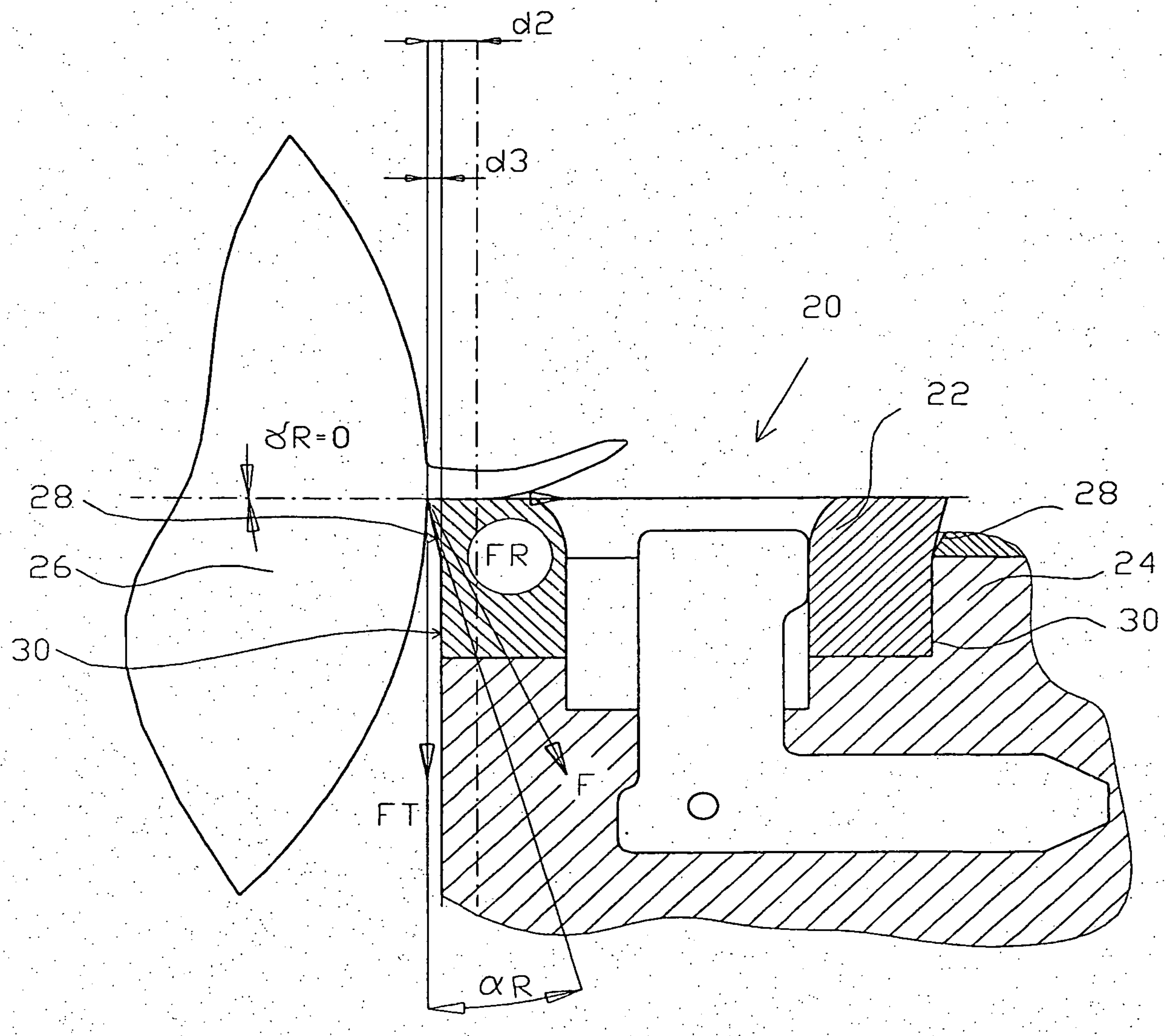

FIG. 4

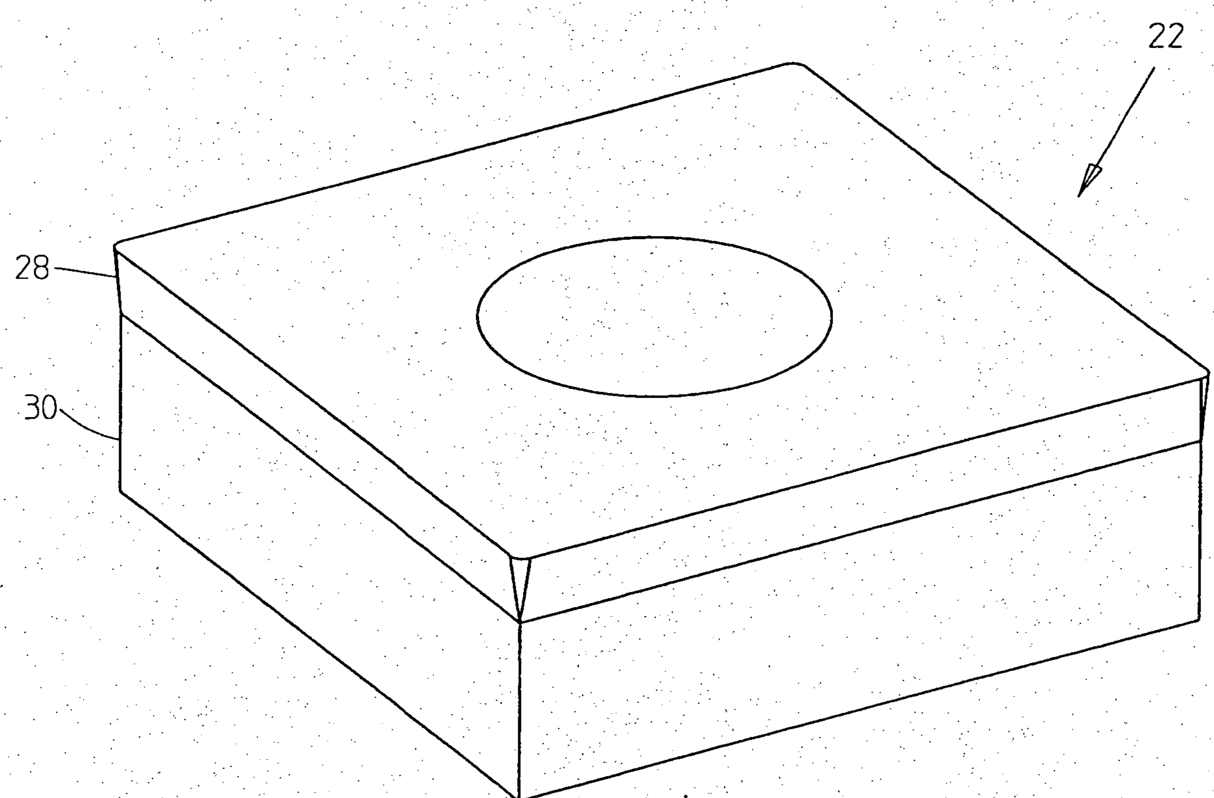

FIG. 5

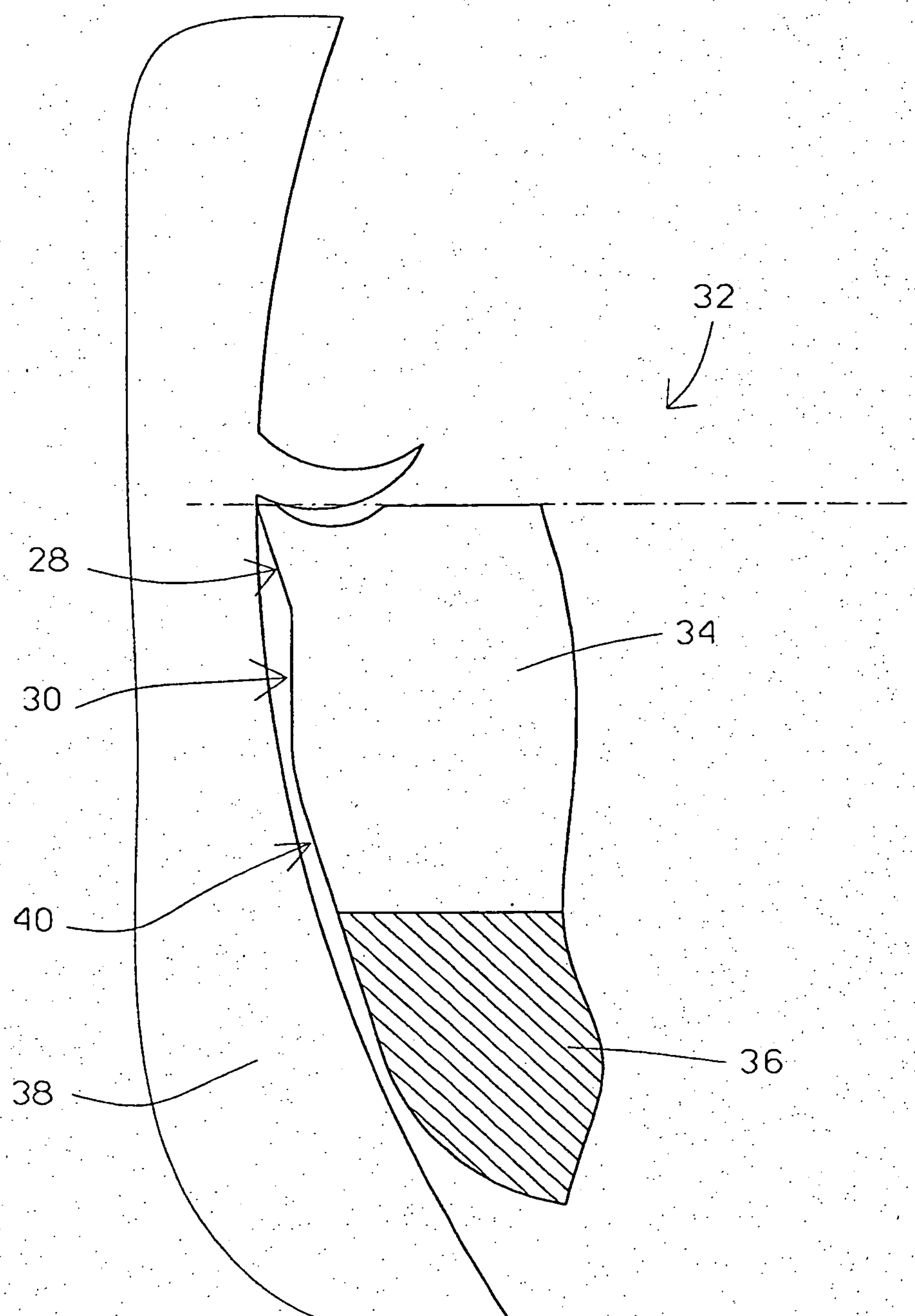

FIG. 6

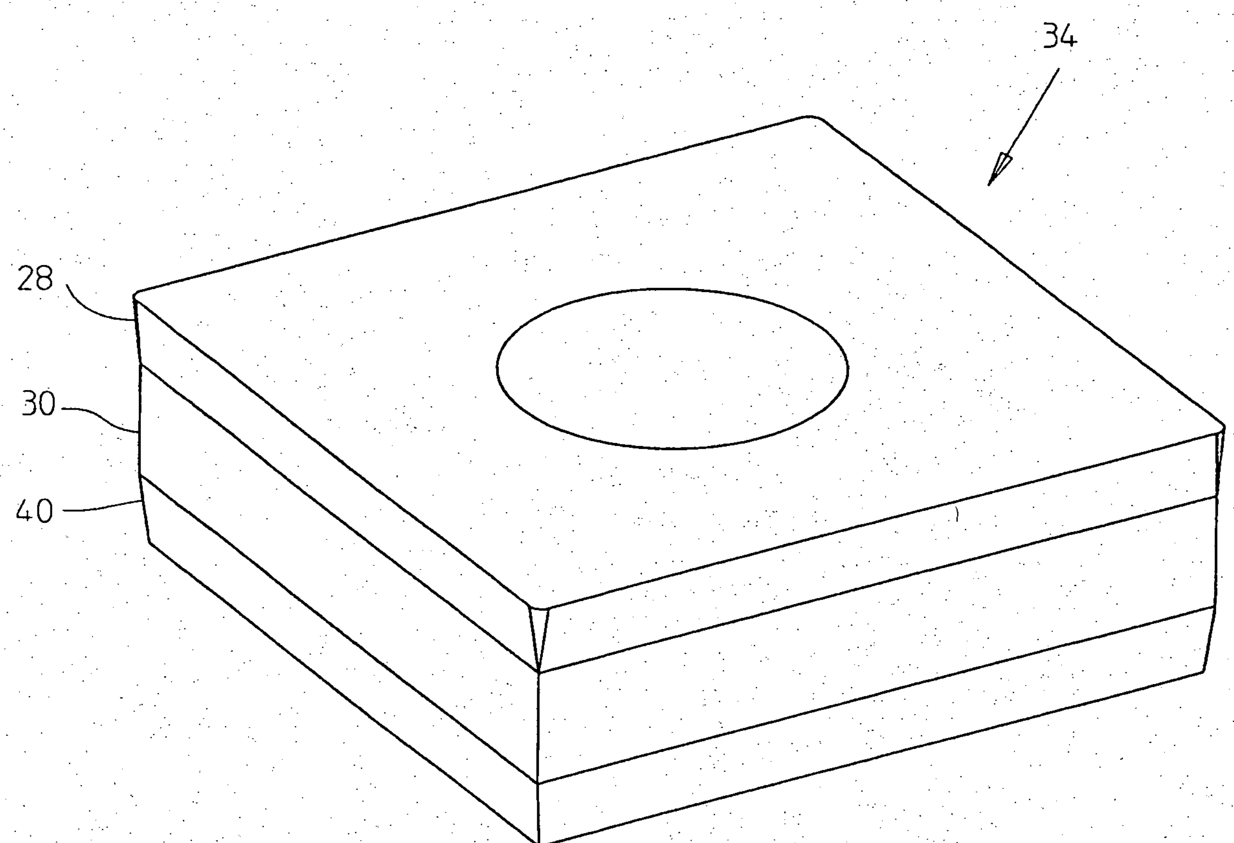

FIG. 7A

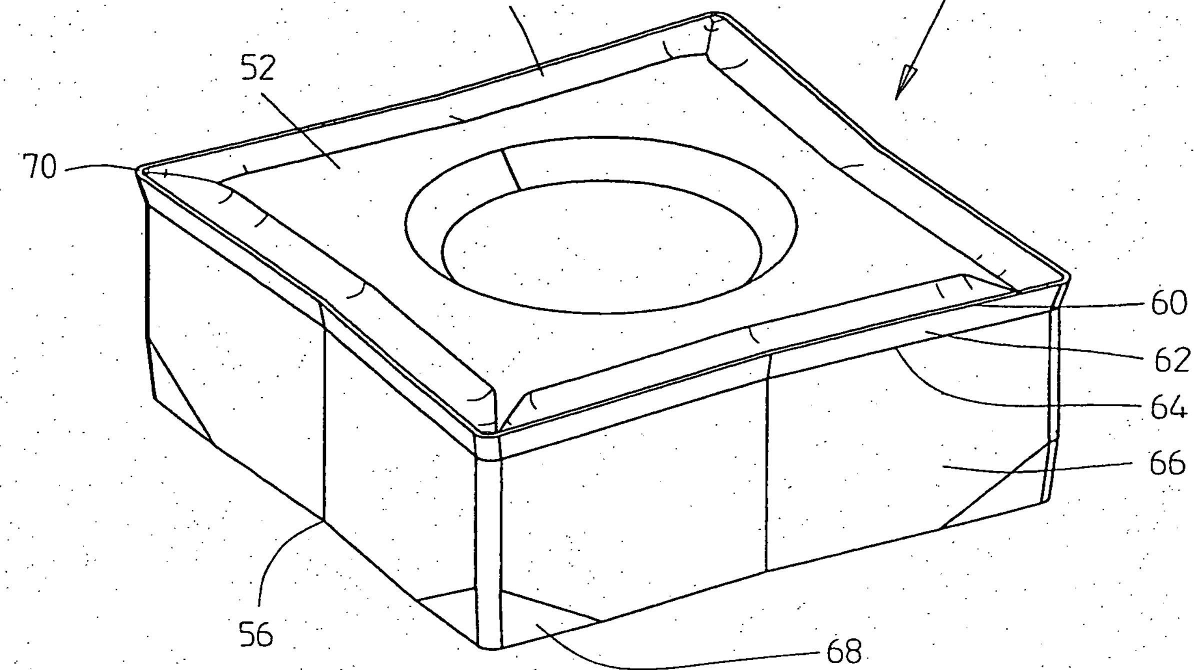

FIG. 7B

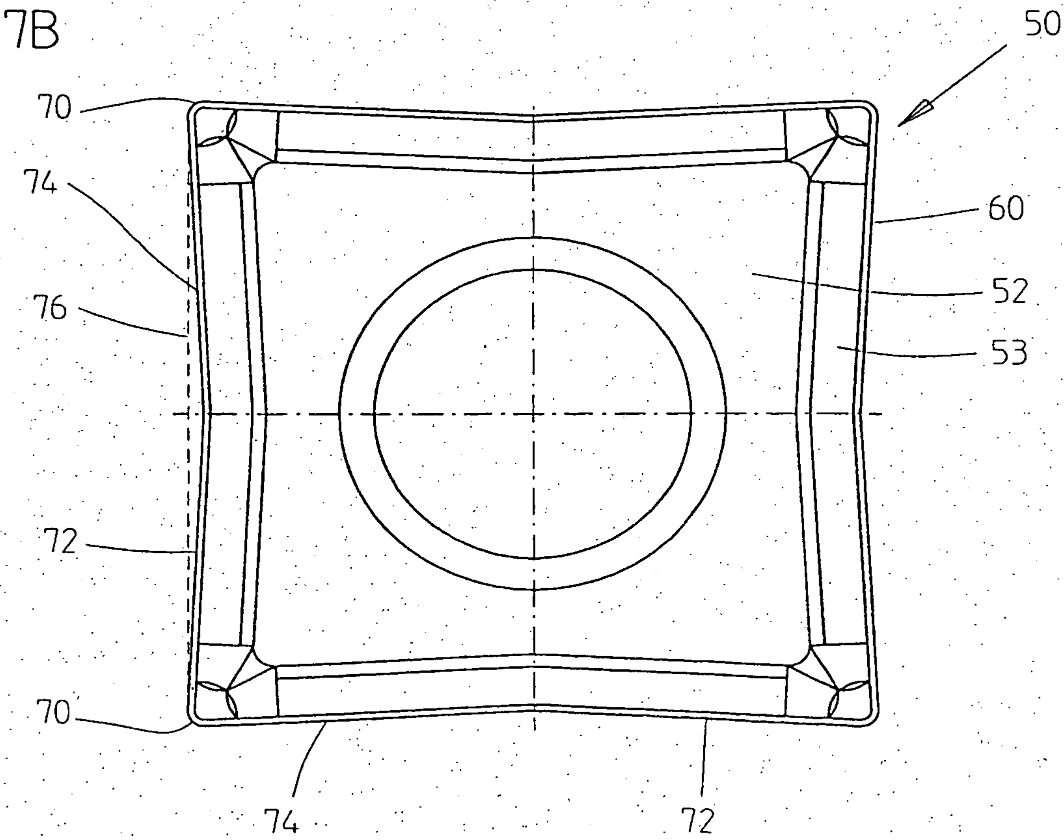

FIG. 7C

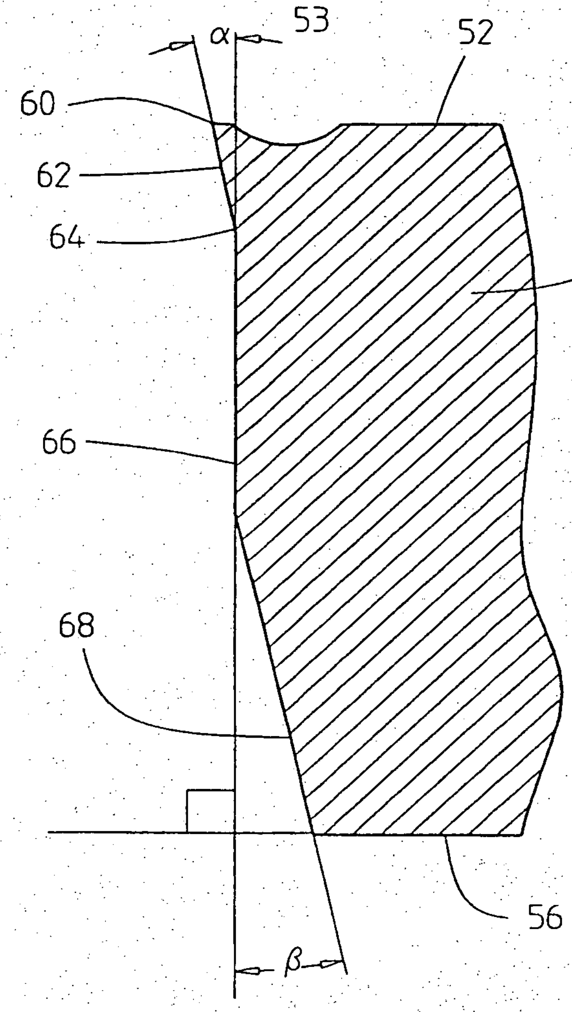

FIG. 7D

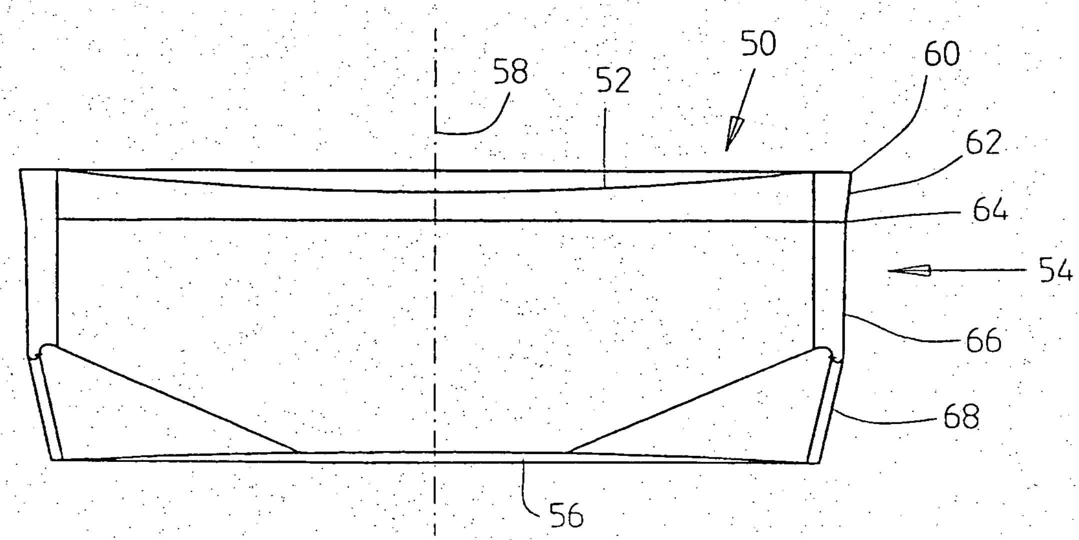

FIG. 8A

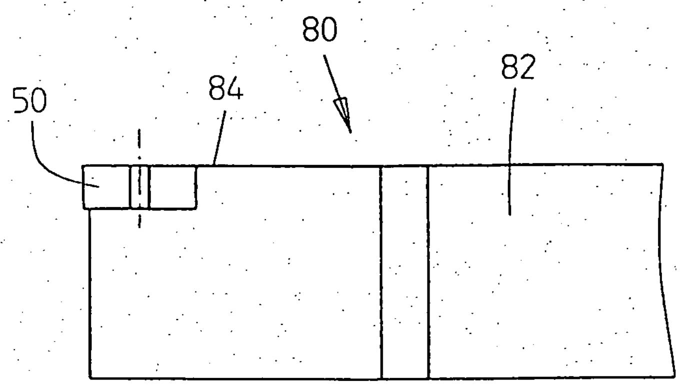

FIG. 8B

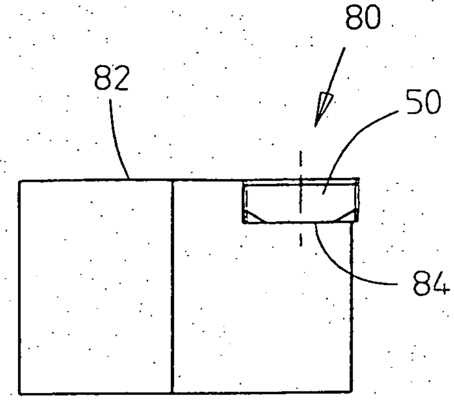

FIG. 8C

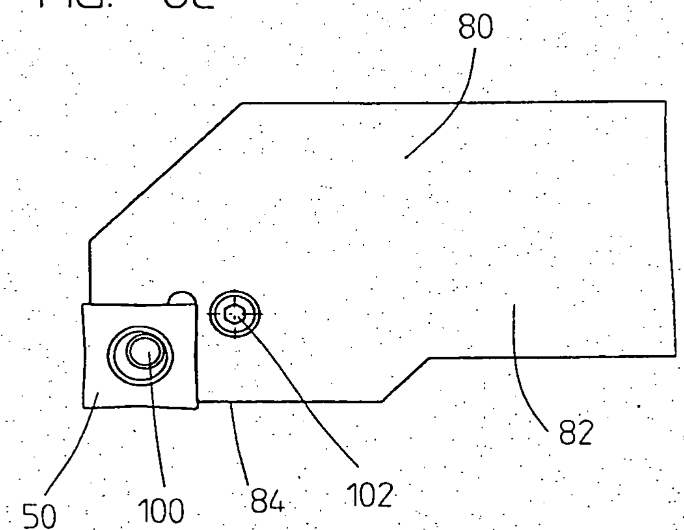

FIG. 9A

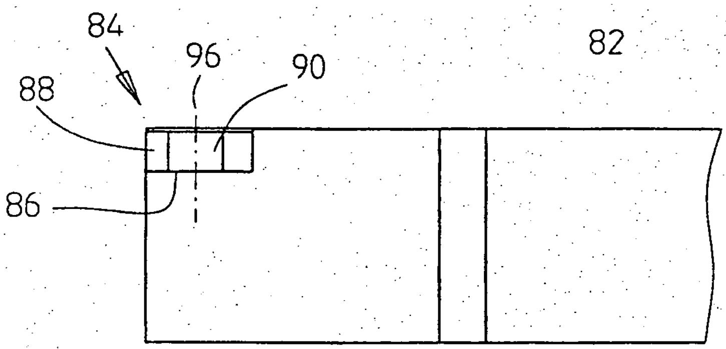

FIG. 9B

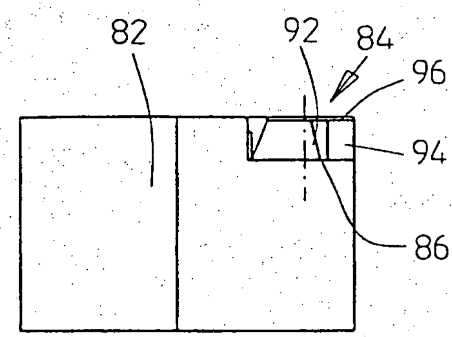

FIG. 9C